VIA MEDICA

ORIGINAL PAPER / GYNECOLOGY

Ginekologia Polska
2018, vol. 89, no. 11, 581–586

ISSN 0017–0011

DOI: 10.5603/GP.a2018.0100

Dietary vitamin and mineral intakes in a sample of pregnant women with either gestational diabetes or type 1 diabetes mellitus, assessed in comparison with Polish nutritional guidelines

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ABSTRACT

Objectives: Maintaining proper nutrition during pregnancy is crucial for pregnant women and especially for who have been diagnosed with type 1 diabetes mellitus (T1DM) or who develop gestational diabetes mellitus (GDM).

Material and methods: To measure differences in vitamin and mineral intakes among women with normal pregnancies, pregnant women with GDM, and pregnant women with pre-gestational T1DM; and to assess the women's dietary intakes in comparison with Polish nutritional guidelines.

The analysis was conducted among 83 pregnant women (29 GDM patients, 26 T1DM patients and 28 normal pregnancy participants) from whom we collected seven-day 24-hour dietary records during the second part of their pregnancies.

Results: There were no statistically significant differences observed for most of the vitamin and mineral intakes across the three groups. However, we did observe a significant difference in the vitamin C and calcium intakes between groups. The mean vitamin C and calcium intakes were significantly higher in the control group than among the diabetic patients. Insufficient dietary calcium intakes were found among 52.3% of the GDM patients and 61.6% of the T1DM participants, while only 28.6% of the normal pregnancy patients experienced a calcium deficiency. The highest incidence of inadequate intake in each of the GDM, T1DM and control groups was observed for vitamin D (100%, 100%, 100%), folate (97.7%, 100%, 100%), iron (97.7%, 100%, 100%), and iodine (97.7%, 92.4%, 85.7%), respectively.

Conclusions: Diet alone may not be enough to provide adequate levels of vitamins and minerals for most micronutrients. Supplement use reduces the risk of inadequate intake for many micronutrients, but diet-related issues during pregnancy and pregnancy diagnosed with diabetes remain, and they deserve to be addressed during public health interventions.

Key words: maternal diet; GDM; T1DM; vitamins intakes; minerals intakes

Ginekologia Polska 2018; 89, 11: 581–586

INTRODUCTION

Both observational and experimental studies have identified the maternal diet as a major modifier of the development of regulatory systems in babies both in utero and postnatally. Early maternal nutrition is an important environmental programming stimulus and any nutritional deficiencies during fetal development may alter physiological functions thereby predisposing the offspring to health disorders in adulthood [1]. Furthermore, inadequate nutrient intake during pregnancy may lead to anemia, congenital malformations, preterm deliveries and other serious pregnancy complications and it is also known to increase morbidity and mortality rates [2, 3].

Higher-than-normal energy intakes are recommended during pregnancy and these should help meet the mother's basic nutritional requirements. Daily pre-pregnancy energy

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intakes should be increased by 360 kcal and 475 kcal in the second and third trimesters, respectively. This relatively small amount of energy should allow pregnant women to achieve the requirement for significantly increased intakes of folic acid, iron, vitamin E, thiamin, niacin, vitamin B12, and vitamin C [4]. For these reasons, the importance of improving the mother's diet during pregnancy warrants particular emphasis [5].

Maintaining proper nutrition during pregnancy becomes even more significant when pregnant women have diabetes. Pregnant women who have developed gestational diabetes mellitus (GDM) or who have been diagnosed with type 1 diabetes mellitus (T1DM) in earlier life are at increased risk of perinatal complications, including macrosomia, birth injuries, shoulder dystocia, perinatal asphyxia, bone fractures, hypoglycemia hyperbilirubinemia, respiratory distress, and hypertrophic cardiomyopathy [6]. Proper dietary intake among pregnant diabetes patients is important not only providing nutrients for maternal health and fetal growth but also for maintaining the mother's proper weight gain and blood glucose levels.

In Poland, the Polish Diabetes Association provides general guidance to pregnant women with GDM or T1DM on clinical nutritional therapy by [7]. However, Polish guidelines on the management the dietary needs of diabetic patients are only focused on macronutrients themselves and not on micronutrients intake. Detailed guidelines on vitamins and minerals required by pregnant women are included in the nutritional guidelines for human nutrition made by the Polish Institute of Food and Nutrition [4]. However, research that assess nutritional intakes among women with GDM or pre-gestational T1DM has been limited, leading to lack of understanding of what the actual nutritional intakes are across this population of patients. To the best of our knowledge, no study has assessed the adequacy of diabetic-specific intakes in relation to current nutritional guidelines. Therefore, the purpose of our study was to measure any differences in vitamin and mineral intakes between groups of GDM, T1DM and normal pregnancy patients, and to assess the pregnant women's dietary intakes in comparison with current Polish nutritional guidelines. This study could also lead to a proposal to develop proper nutritional education programs to aid the prevention of vitamin and mineral related problems that pregnant women with GDM and T1DM are likely to face during their pregnancies.

MATERIALS AND METHODS

Study Population

113 of pregnant women with a gestational age greater than 20 weeks of pregnancy were recruited by personnel of the 1st Department of Obstetrics and Gynaecology and the Department of Social Medicine and Public Health at the Medical University of Warsaw, between September 2016 and March 2018. The subjects' clinical histories were recorded, and each underwent a physical examination. Patients were divided into type 1 diabetes, GDM and normal pregnancy groups at the time of recruitment. However, we excluded those with acute and chronic organ diseases, and women younger than 18 years old. Our final sample included 83 pregnant women divided into three groups: P1 consisted of 29 GDM patients, P2 of 26 T1DM patients, and P3 of 28 normal pregnancies. P3 was our control group. The study recorded nutritional data during the second part of each woman's pregnancy. The study protocol was approved by the Ethical Committee of the Medical University of Warsaw and all subjects gave their written consent to participate in the study.

Dietary Data and Estimated Energy Requirement

Each woman's vitamin and mineral intake was assessed based on self-reported 7-day 24-hour dietary records of their food consumption and these records were checked by trained investigators in a face-to-face interview. Dietary intake data from the seven-day dietary records was converted into energy and nutrient intake data using dietetic software 'Dieta 5' reflecting the Polish Food Composition [8]. The 'Dieta 5' database does not provide information on dietary and prenatal supplements. We examined the intakes of vitamin A, β-Carotene, vitamin E, thiamin, riboflavin, niacin, vitamin B6, vitamin C, folate, vitamin B12, vitamin D, sodium, potassium, calcium, phosphorus, magnesium, iron, zinc, copper, manganese and iodine. Both the estimated average requirement (EAR) and adequate intake (AI) were based on and consistent with the Polish Institute of Food and Nutrition guidelines [4].

Statistical Analyses

The data were collected in a prospective database and analyzed. Within each group of patients, means and standard deviations for micronutrients were calculated from the 7-day 24-hour dietary reports. We calculated the proportions of women with values below the EARs. Statistical analyses were performed using SPSS Statistics 20 (IBM, Armonk, NY, USA), Epi Info Version 7.2 (CDC, USA) and Microsoft Excel (Redmond, WA, USA). Finally, an ANOVA test was carried out to assess variations in vitamin and mineral intakes between the three groups.

RESULTS

Participant characteristics are presented in Table 1. Of the 113 pregnant women recruited, thirty were lost during follow-up, mainly due to their lack of time to devote to the project. Therefore, our results include data from 83 pregnant women with a mean age of 32.1 ± 4.3 years and an average

Table 1. Participants' characteristics

Variable	All (n = 83) Mean ± SD	P1 (n = 29) Mean ± SD	P2 (n = 26) Mean ± SD	P3 (n = 28) Mean ± SD	p-value
Age [y]	32.1 ± 4.3	31.5 ± 4.1	32.6 ± 5.3	32.2 ± 3.7	0.62
Gestational age [weeks]	29.2 ± 4.0	28.9 ± 3.7	28.3 ± 5.8	30.1 ± 1.5	0.27
Height [cm]	166.3 ± 5.7	165.4 ± 5.9	168.2 ± 6.0	165.8 ± 5.1	0.20
Weight [kg]**	75.0 ± 15.8	75.9 ± 19.6	77.7 ± 18.0	72.0 ± 7.5	0.41

* p-value for measures ANOVA carried out to assess variations in the characteristic between the groups; group P1 — GDM patients; group P2 — T1DM patients; group P3 — normal pregnancy patients
** body weight at inclusion in the study; data concerning reliable pre-pregnancy body mass was not available

gestational age of 29.2 ± 4.0 weeks. All the participants were Caucasian.

Vitamins Minerals and β-Carotene Intake

Data on the micronutrient intakes derived from the 7-day 24-hour reports and the proportions of women who reported intakes below the corresponding EARs are shown in Table 2 and Table 3. No statistically significant differences were observed for most of vitamin and mineral intakes across the three groups. However, we did observe a significant difference in the vitamin C and calcium intakes. The mean vitamin C and calcium intakes were significantly higher in the control group than in the two groups of diabetic patients. When we analysed food sources only across all groups, we observed a high incidence of inadequate intakes for vitamin D (100%, 100%, 100%), folate (97.7%, 100%, 100%), iron (97.7%, 100%, 100%), iodine (977%, 924%, 857%) – percentages are for groups P1, P2 and P3 respectively. Vitamin E intakes were below the AI for 69.8%, 50% and 67.8% of the women in the first, second, and third group, respectively. Furthermore, calcium intakes were below the EAR for 52.3%, 61.6% and 28.6% of patients in the P1, P2 and P3 groups, respectively. More than 40% of all women reported insufficient levels of thiamine consumption. Smaller proportions of women reported inadequate intakes of riboflavin, niacin, vitamin B6, vitamin B12, vitamin C and copper (Tab. 3, 4). In all groups more than 75% of the pregnant women reported sodium intakes that were above the Tolerable Upper Intake Level (UL) of 2300 mg. We observed large variances in the β-Carotene intake quartiles.

DISCUSSION

It is essential for pregnant women, including those diagnosed with GDM or T1DM, to meet basic nutritional requirements to ensure the health and wellbeing of both mother and child. Our prospective assessment of pregnant women's dietary intakes assessed the diabetic-specific adequacy of current nutritional Polish guidelines. Such an investigation is important because some groups of food products are not recommended for during pregnancy complicated by diabetes, which can in turn result in some vitamin and mineral deficiencies arising.

Anaemia, due to iron deficiency, is one of the most prevalent micronutrient deficiencies globally. According to 2011 estimates, the worldwide incidence of anaemia in pregnant women was measured at 38%, which translates into 32 million pregnant women worldwide [9, 10]. Alarmingly, when we observed the women's food and fluid intakes, almost all the pregnant women in our study showed insufficient intakes of iron, folate and vitamin D. These results are similar to those reported by Savard et al., Dubois et al., and Maimaitiming et al. [11–13]. In addition, the study reported by Lim et al. indicated that the actual intake levels of a GDM group of women were lower than the recommended levels for almost all micronutrients [14]. Our results, when considered alongside those of other epidemiological studies, therefore suggest that the use of multivitamin supplements during pregnancy is still necessary to reduce the risk of pregnant women's intake of micronutrients being inadequate. Current Polish nutrition guidelines for folate are consistent with levels set by most other countries [15]. There is evidence that folic acid supplements taken during pregnancy decrease the risk of stillbirth, as shown in a comparative study of the use of low- and high-folic acid supplement dosages among pregnant women in Spain (RR 0.92, 95% CI 0.85 to 0.99, n = 79.851 participants)[16].

Many studies have shown that iodine deficiency during pregnancy, even at moderate levels, creates a risk of the delayed development and maturation of the fetal brain, ranging from mild intellectual blunting to frank cretinism; and that iodine deficiency is therefore a major preventable cause of mental defects [17]. The iodine needs of pregnant women (≥ 160 μg/day) exceeds those of the general population (≥ 95 μg/day) [4]. Though the worldwide data for pregnant women is scarce, what there is indicates a widespread maternal iodine insufficiency [18]. In our study iodine intake was insufficient in more than 85% of our participants. However, it should be noted that Poland introduced a universal salt iodization programme in 1997 and this has achieved the goal of eliminating iodine deficiency disorders in the

Table 2. Group-specific vitamin intakes from food alone in comparison with dietary reference intakes

	EAR	AI	GR	Mean ± SD	Min.	25%	Median	75%	Max	% Below EAR or AI	P-value*
Vitamin A µg RAE / day	900	-	P1	1009.0 ± 348.3	602.3	720.3	827.8	1200.6	1669.4	55.8	0.13
			P2	987.6 ± 286.8	368.5	714.2	1022.5	1179.4	1520.8	26.9	
			P3	1205.9 ± 602.9	527.8	728.5	1148.1	1639.8	2639.9	42.8	
β-Carotene µg / day	-	-	P1	3825.2 ± 1702.3	1560.8	2597.2	3413.6	4819.5	7342.3	-	0.20
			P2	3919.7 ± 1573.8	1423.7	2472.3	3956.3	4962.0	7169.5	-	
			P3	4851.3 ± 3356.7	1555.5	2201.7	3749.3	6416.0	12493.2	-	
Vitamin E mg EAT / day	-	10	P1	9.6 ± 2.9	5.0	8.2	8.9	10.7	16.9	69.8	0.40
			P2	10.9 ± 5.0	5.5	8.3	10.0	12.4	31.7	50.0	
			P3	9.7 ± 3.7	5.0	6.8	9.0	11.5	20.9	67.8	
Thiamin mg / day	1.2	-	P1	1.4 ± 0.5	0.9	1.1	1.3	1.7	3.1	41.8	0.06
			P2	1.2 ± 0.4	0.5	0.9	1.1	1.5	2.0	61.6	
			P3	1.3 ± 0.3	0.7	1.0	1.3	1.5	2.3	42.8	
Riboflavin mg / day	1.2	-	P1	1.8 ± 0.4	1.1	1.5	1.7	2.0	2.9	3.5	0.33
			P2	1.7 ± 0.5	0.7	1.4	1.7	1.9	2.6	19.2	
			P3	1.9 ± 0.4	1.1	1.5	1.8	2.3	2.7	7.1	
Niacin. mg / day	14	-	P1	22.6 ± 17.0	8.6	12.9	18.3	24.2	96.1	31.4	0.11
			P2	17.5 ± 5.2	8.7	14.2	16.7	20.1	29.8	23.1	
			P3	17.1 ± 6.1	7.3	14.5	16.4	17.7	34.7	25.0	
Vitamin B6 mg / day	1.6	-	P1	2.0 ± 0.8	1.0	1.5	1.8	2.3	5.3	31.4	0.51
			P2	1.8 ± 0.4	1.1	1.5	1.8	2.2	2.6	30.8	
			P3	1.9 ± 0.5	1.0	1.6	1.8	2.2	3.2	25.0	
Vitamin C mg / day	70	-	P1	99.5 ± 46.3	33.2	65.8	85.7	134.6	214.0	27.9	0.04
			P2	108.9 ± 50.0	52.7	72.7	86.2	153.8	205.4	23.1	
			P3	134.9 ± 64.4	36.6	85.7	118.0	174.4	297.7	14.3	
Folate µg DFE / day	520	-	P1	296.1 ± 96.7	146.5	244.0	275.4	343.9	541.8	97.7	0.38
			P2	268.3 ± 73.4	151.7	216.1	256.2	320.9	449.1	100	
			P3	294.3 ± 71.0	139.0	246.3	291.0	334.7	471.1	100	
Vitamin B12 µg / day	2.2	-	P1	3.9 ± 1.8	2.1	2.8	3.4	4.2	10.9	3.5	0.86
			P2	3.8 ± 1.5	0.7	3.0	3.7	4.5	7.4	19.2	
			P3	4.1 ± 1.2	1.8	3.2	4.2	4.8	6.8	14.3	
Vitamin D µg / day	-	15	P1	3.2 ± 2.1	1.0	1.9	2.9	3.5	12.6	100	0.22
			P2	3.7 ± 2.4	1.2	1.7	2.7	5.2	8.8	100	
			P3	2.7 ± 1.8	0.7	1.6	2.1	3.2	9.7	100	

* p-value for measures ANOVA carried out to assess variations in micronutrient intakes between groups. When no EAR or AI was established for a nutrient. The "-" sign is used instead of a 0; GR — Group of patients where P1 — GDM patients; P2 — T1DM patients; P3 — normal pregnancy; EAR — estimated average requirement; AI — adequate intake; DFE— dietary folate equivalent; RAE — retinol activity equivalents

population [19]. One important limitation of iodine intake in our study was that not all food sources of iodine are considered, for instance, iodized water is excluded, in the 'Dieta 5' databased used in our analysis. Moreover, in Poland, preventative programs aimed at hypertension, type 2 diabetes, atherosclerosis, osteoporosis and some neoplastic diseases include limitations on the level of salt (natrum chloride) consumption. However, most of the women in our study (75%) had sodium intakes above the Tolerable Upper Intake Level (UL). This result corresponds with the Savard et al. investigation where more than 85% of the pregnant women studied exceeded the sodium UL intake. Therefore, public health advocates ought to coordinate programs to reduce salt intake and prevent iodine deficiency [20].

Dietary intakes of riboflavin, copper, vitamin C and vitamin B12 were below the Estimated Average Requirements (EARs) for 3.5% to 30% of all women. There were significant differences in calcium consumption between the groups. Insufficient dietary calcium intakes were found among 52.3% of the GDM patients and 61.6% of the T1DM participants,

Table 3. Group-specific mineral intakes from food alone in comparison with dietary reference intakes

	EAR	AI	GR	Mean ± SD	Min.	25%	Median	75%	Max	% Below EAR or AI	P-value*
Sodium mg / day	-	1500	P1	3134.6 ± 648.6	1706.9	2643.8	3139.2	3521.2	4988.7	-	0.57
			P2	3318.9 ± 771.0	2060.3	2867.4	3265.4	3733.5	4910.7	-	
			P3	3133.3 ± 770.3	1902.7	2547.8	3021.8	3646.5	5427.8	-	
Potassium mg / day	-	3500	P1	3773.5 ± 2423.9	1984.7	2689.5	3081.4	3848.9	14728.3	69.8	0.24
			P2	3100.94 ± 728.4	1768.5	2653.9	3048.8	3775.0	4650.4	73.1	
			P3	3261.21 ± 753.7	1915.2	2754.3	3167.1	3548.0	4843.3	35.7	
Calcium mg / day	800	-	P1	785.8 ± 264.2	329.7	595.6	778.3	958.5	1282.5	52.3	0.01
			P2	694.6 ± 263.7	196.1	483.3	707.1	862.8	1317.7	61.6	
			P3	959.0 ± 322.0	337.8	721.7	919.8	1198.9	1746.2	28.6	
Phosphorus mg / day	580	-	P1	1643.0 ± 666.6	955.5	1214.4	1402.0	1858.4	4298.3	-	0.07
			P2	1371.8 ± 349.0	477.6	1197.5	1356.0	1499.1	2056.9	3.8	
			P3	1400.9 ± 332.6	807.1	1157.3	1409.8	1619.4	2184.9	-	
Magnesium mg / day	300	-	P1	359.7 ± 114.9	197.5	285.9	329.5	424.3	650.0	27.9	0.20
			P2	313.6 ± 87.0	159.6	251.2	302.2	362.9	518.6	50.0	
			P3	346.7 ± 85.8	180.6	296.4	349.5	408.6	509.5	25.0	
Iron. mg / day	23	-	P1	12.9 ± 5.5	7.1	9.4	11.6	13.6	34.6	97.7	0.10
			P2	10.6 ± 2.5	5.6	9.5	10.3	11.7	16.7	100	
			P3	11.7 ± 3.1	7.0	9.1	11.2	13.7	19.9	100	
Zinc mg / day	9.5	-	P1	11.7 ± 2.7	8.0	9.5	11.1	13.8	18.8	27.9	0.37
			P2	10.7 ± 2.6	4.3	9.1	10.9	12.0	17.5	27.0	
			P3	11.0 ± 3.0	7.0	9.4	10.5	12.3	20.3	32.1	
Copper mg / day	0.8	-	P1	37.3 ± 0.4	0.7	1.1	1.2	1.5	2.4	3.5	0.28
			P2	29.7 ± 0.3	0.6	0.9	1.1	1.2	2.1	7.7	
			P3	35.0 ± 0.3	0.7	1.1	1.2	1.5	1.9	7.1	
Manganese mg / day	-	2.0	P1	6.0 ± 2.0	2.3	4.9	6.0	7.2	11.1	-	0.29
			P2	5.3 ± 1.8	2.5	3.6	5.9	6.4	9.1	-	
			P3	5.3 ± 2.2	2.7	3.8	5.0	6.6	12.6	-	
Iodine µg / day	160	-	P1	107.3 ± 30.4	39.4	88.8	107.4	119.9	165.9	97.7	0.39
			P2	119.9 ± 33.8	69.2	90.4	119.1	138.8	201.3	92.4	
			P3	114.9 ± 37.4	60.4	94.8	103.2	130.3	227.5	85.7	

* p-value for measures ANOVA carried out to assess variations in mineral intakes between group. When no EAR or AI was established for a nutrient. The "-" sign is used instead of a 0; GR— Group of patients where P1 — GDM patients; P2 — T1DM patients; P3 — normal pregnancy; EAR — estimated average requirement; AI — adequate intake

while only 28.6% of the normal pregnancy patients experienced calcium deficiency. We observed that some of our diabetic patients declared the elimination of milk to avoid food-related postprandial hyperglycemia. Although, it is well known that dairy foods (i.e., milk, yogurt, and cheese) and dairy proteins (i.e., casein and whey) share many functional properties and physiologic effects among diabetic patients, it is also likely that they differ in their metabolic effects primarily because of their different absorption kinetics, micronutrient content, and concentration of bioactive components [21].

Our study has certain limitations. The most substantial limitation was the small size and the lack of representativeness of our study sample, however all pregnant women enrolled were Caucasians and of a similar age. Another limitation was that the observational design did not permit the establishment of causality. Finally, our study did not measure circulating 25(OH)D in addition to iron, folate and iodine status, which limited the adequacy of our assessment of the pregnant women's vitamin D, iron, iodine and folate intakes. However, to the best of our knowledge, previous research has never focused on vitamin and mineral intakes in pregnant Polish women, patients diagnosed with GDM during pregnancy, or pregnant women with pre-gestational T1DM. One of the evident strongpoints of our study is the fact that it is the first to prospectively assess whether pregnant women and pregnant women with diabetes meet the current Polish nutritional guidelines. Furthermore, this study helps to remedy a lack of available information in Poland about the vitamin and mineral intakes by pregnant women. Finally, the results have shown that dietary intakes from food are not sufficient to meet all the vitamin and mineral requirements, whereby prenatal supplementation should be considered to reduce the risk of inadequate intakes for most micronutrients. In this regard, the results obtained are original as well as clinically and epidemiologically important.

CONCLUSION

In summary, this study, contrary to current guidelines, has shown that vitamin and mineral intakes among pregnant women, patients diagnosed with GDM during pregnancy, and pre-gestational T1DM were very similar. We also found that diet alone may not be sufficient to provide adequate intakes for the majority of micronutrients. Supplement use reduces the risk of inadequate intakes for many micronutrients, but diet-related issues during pregnancy and pregnancies diagnosed with diabetes remain, and these deserve to be addressed in public health interventions. Though combining micronutrient supplements has been suggested as a cost-effective way to achieve benefits for women during pregnancy, this should only be done with full awareness of the efficacious combinations and doses and of the risks of certain combinations, because overconsumption of some nutrients may also cause harm to the mother or her baby. This study could also lead to a proposal to develop proper nutritional education programs to aid the prevention of vitamin and mineral related problems that pregnant women with GDM and T1DM are likely to face during their pregnancies.

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